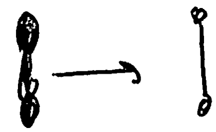
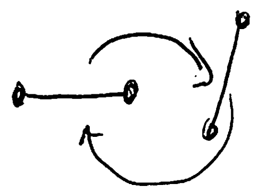
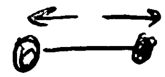
Kinetic Theory - particles of matter always in motion, which has consequences

Types of Motion

1 Translational 

2. Rotational 

3 Vibrational

 Stretch

 bend

Liquids, gases behave to all 3

Solids 3 only

Gases Kinetic-Molecular Theory of Gases

↳ Assumes all gases behave as an ideal gas

Ideal Gas - "imaginary" gas that conforms to all assumptions of K. Theory

HMWK pg 2

Do not exist really but most almost behave this way so its cool

DEMOS for Gases

Pre-Demo Discussion

As you do the demonstrations, ask students to:

1. try to predict the outcome of the demonstration;
2. carefully observe the demonstration and, if necessary, account for differences between your prediction and the actual outcome;
3. try to identify the specific gas property that is being demonstrated, and why gases exhibit this property; and
4. think of practical consequences of atmospheric gases' exhibiting this property.

Demo Tips

1. When performing the demonstrations be sure to capitalize on the element of surprise.
2. Avoid forecasting expected outcomes to your students.
3. On several demonstrations you may wish to elicit ideas on what will occur and why. For others, you may wish to do the demonstration before eliciting student response.
4. You do not need to try to "teach" concepts on this day; all will be developed more fully in subsequent text and activities.
5. The main purpose at this time is to raise questions and motivate your students to want to learn more about the "sea" of gases in which we live.

The following demonstrations have been chosen for several reasons:

1. They are effective for illustrating that gases (even colorless, odorless ones) are "real" substances.
2. They draw students' attention to very important properties of our atmosphere in a dramatic fashion.
3. They use readily available materials.
4. If properly performed, they are quite safe—in fact, you may encourage your students to repeat some of the demonstrations for themselves at home.
5. They do not require elaborate setups or much advance setup time—the entire sequence can be performed between the first and second days of the unit.

Answers to Questions:

Is air really matter?

Demonstration 1: Air has weight Balance two filled balloons by hanging them from a meter-stick balance. Pop one of the balloons and note the direction of the balance's tilt. Though "invisible," gases do possess weight, like other forms of matter.

Demonstration 2: Air occupies space Lower an "empty" glass, open end downward, into a larger beaker (or pot) of water. Does water fill up the "empty" glass? Tilt the glass. What happens? Does air occupy space? Lead your students to realize that even colorless gases occupy space.

Demonstration 3: Not all gases are colorless Place several crystals of iodine in a sealed flask. A faint purple color will soon be observed in the flask above the crystals. (This is best displayed with white paper behind the flask.) Contrast this "colored gas"–iodine vapor, $I_2(g)$–to air or other colorless gases.

What is air pressure all about?

Blow up Balloon in Bottle

Demonstration 4: Air has pressure Select a balloon that is easy to blow up. Put the balloon inside a volumetric flask or an empty soft drink bottle and stretch its neck over flask or bottle mouth. Ask a talkative student to try blowing up the balloon so it fills the container as in the above experiment. Ask the class to explain the difficulty of this task.

Heat Balloon in flask

Demonstration 5: Temperature changes the air pressure Before class, place 10 mL water in a 250-mL Erlenmeyer flask. Bring the water to boiling. Remove the flask from the source of heat and quickly place an empty balloon over the mouth of the flask. As the flask cools, the pressure differential between the outside and inside of the flask will cause the balloon to invert and line the inside walls of the flask. In class, ask your students to explain how the balloon was placed inside the flask and for suggestions on how to remove the balloon from the flask. Note that heating will cause the liquid water to vaporize and push out the balloon. This demonstration is also effective if performed "live." Students seem to enjoy the demonstration even more if the balloon pops before completely filling the flask.

Demonstration 6: Air exerts pressure upward and in all directions Fill a glass to the rim with water. Cover this with either wax paper or a piece of cardboard (as cut from a cereal box). Press down along the edges to make a tight seal, turn the glass upside down over a sink, and let go of the cover. Air pressure (acting upwards against the covering) will support the weight of the water and prevent it from spilling out. Repeat the process without filling the glass completely.

Ask your students to account for the difference in the two cases.

Demonstration 7: Air exerts pressure sideways and in all directions Punch a small hole in the side of an empty, clean, plastic bottle (such as a liquid-detergent bottle). Holding your finger over the hole, completely fill the bottle with water. Replace the cap. Remove your finger from the hole. Explain your observation. Unscrew the lid and note what happens. Ask students to account for the difference. Why is it difficult to pour juice from a can if only one hole is punched in it?

Demonstration 8: Air exerts pressure in all directions Place about 20 mL water in a clean, empty aluminum soft drink can. Bring the water to a rapid boil and quickly invert the can in a container of water. It is not necessary to submerge the can, but only to have its top touch the water's surface. The boiling process will force out much of the air that is inside the can and replace it with water vapor. Upon cooling, the water vapor will condense, leaving a partial vacuum inside the can. Atmospheric pressure outside the can will crush it. In addition to demonstrating the substantial pressure of our atmosphere, this demonstration contrasts the relative densities of liquid and gaseous states of matter. You may wish to reserve it for that purpose. If duplicating-fluid cans are still available in your school, you may wish to do the demonstration with an empty one. Add about 100 mL of water to the can, heat the water to boiling, and then seal the can with a rubber stopper. The advantage of this method is that the crushing of the can is more prolonged, and partially reversible; you can restore the shape of the can by blowing into it.

Why does air sometimes carry odors?

Demonstration 9: Diffusion of gases Standing at the front of the classroom, open a bottle of perfume or other safe, odoriferous substance with high vapor pressure. Have each student raise a hand as soon as the odor is detected.

Demonstration 10: Diffusion rates of gases Place two small beakers (one containing ammonia, the other, water and phenolphthalein) under a large plastic or glass container. Ask your students to account for any changes they note. (You will see a pink ring forming nearing the water surface.) Placing the setup on an overhead projector will make it more visible and cause the diffusion to occur faster. A similar demonstration using hydrochloric acid and ammonia (to produce ammonium chloride "smoke" particles) can also be performed with this setup or with the traditional long glass tube setup.

Is air heavy? Will it burn?

Demonstration 11: Density Contrast the behavior of equal sized balloons filled with available gases such as hydrogen (0.09 g/L), helium (0.18 g/L), natural gas from a burner jet which is mainly methane (0.55 g/L), "air" (1.0 g/L), carbon dioxide (2.0 g/L), or sulfur hexafluoride (SF_6–6.6 g/L) by attempting to throw them. Alternative and especially effective demonstrations include: (a) "blowing bubbles" using a liquid soap-glycerin mixture and a funnel connected via rubber tubing to a gas source and (b) pouring carbon dioxide down a tilted tray of candles. Or, simply observing a container of dry ice is also effective.

Demonstration 12: Flammability Contrast the flammability of hydrogen (or methane) to that of helium, using either balloons or soap bubbles. If using the soap bubble approach be sure to run enough gas through the tubing to clear out any air. This precaution will insure even, rapid, nonexplosive burning. Use a candle attached to a meter stick to attempt igniting the bubbles after they detach themselves from the bubble generator and begin to rise.

At-Home-Activities

1. A straw enables one to suck fluids "uphill" against gravity by using atmospheric pressure. In sucking, air pressure is decreased at the end of the straw in one's mouth. The greater pressure acting on the surface of the fluid pushes the fluid up. If two straws are used in the manner described, one cannot build up a difference in pressure and therefore the fluid does not rise. Some of your brighter students may use their tongue to close off the end of the second straw and thereby be able to accomplish the task.
2. As above, the action of a straw depends on a pressure dif∑ferential. If the container is filled, atmospheric pressure cannot act on the surface of the fluid and the fluid will not rise.

Post-Demo Discussion

Additional ideas you may wish to use on the first and second days include:

1. newspaper or magazine clippings relating to the atmosphere, climate and/or air pollution; and
2. slides of nature-generated air pollution (such as Mt. St. Helens) or human created air pollution—in either case, local or regional "news" will probably have the most impact on your students.

A.3 AIR: THE BREATH OF LIFE (pages 343-344)

This section focuses on oxygen's unique role in the atmosphere, and the reversibility of its supply, being consumed by respiration and produced by photosynthesis. Figure 1 on page 344 is central to the *YOUR TURN* exercise. An enjoyable extension of the *YOUR TURN* questions is to have all students measure their own respiration rates, and use those in all calculations.

☆ Kin Mol Theory

1. Gases consist ~~of~~ of large #'s of tiny particles (atoms or molecules)

   (no Volume constraints) →

2. Particles in a gas are in constant motion → show that of NH_3 + phenol phthalein

3. Gas particles undergo elastic collisions (no loss of KE)

4. No Forces of attraction between particles
   (Billiard Ball Analogy)

5. KE proportional to Kelvin temp of gas

   higher T, higher KE

Ch 11 HMWK pg 319 Q 1, 4, pg 321 Q 2
pg 337 Q 5, 6, 7, 9
pg 339 Prob Q 5, 7, 10, 11
pg 340 Prob 17, ~~20~~
pg 341 App Prob → 7

H p 339 Prob 6, 10, 13
340 16, 21, 28

Props of gases

Expansion - No def. shape takes on shape of surroundings (# 2, 4)

Fluidity - No attractive forces so particles glide smoothly past one another (#4)

Low Density - density of sub. in gas state 1/1000 of in liq of solid B/c molecules so much farther apart

Compressibility - compress gas into liquids (cylinders) particles can be pushed closer together

Diffusion - spread out and mix in absence of currents

Rate of Diffusion depends on ~~size temp~~ speed, diameter, attractive forces

Deviations from ~~Real~~ IDeal behavior

Real Gas → does not obey w/ all ~~a~~ K Theory

Assumptions

~~[illegible]~~

→ Mainly b/c attractive forces (Dipole-Dipole, London Dispersion etc.)

Most Real gases behave as Ideal when molecules are @ high speed / ~~[illegible]~~ far apart

Basically the more polar the gas the ~~[illegible]~~ more real

H_2, N_2 → Nonpolar ideal gas

NH_3, H_2O → Polar Real

Qualitative Description of gases

Show overheads.

→ 4 measures to study gases

1. Volume (V)
2. Pressure (P)
3. temperature (T)
4. number of molecules (moles) (n)

Relation b/ P + V

Pressure ↑ as V ↓ { why? → B/c as V ↓ # of wall

Collisions of molecules ↑ therefore P ↑

the opposites is true

T + V @ constant P

if P is held constant gases expand when heated

+ Contract when cooled

~~when~~ To keep the same P the temperature

must ↑ to keep the # of wall collisions constant.

Pressure + Temp(i

as temp ↑ molecules have more KE. Therefore

~~exact more~~ the # of wall collisions ↑ → P↑

all above @ constant mol

- P + n

more molecules (higher n) higher P

how bike tires inflate.

Volume + moles
@ constant T + P as n↑, V↑ + viceversa

Quantitative (use gas laws)

1st Pressure → Force per unit area on surface

↳ Gas molecules → exert pressure on a surface when they collide w/ it

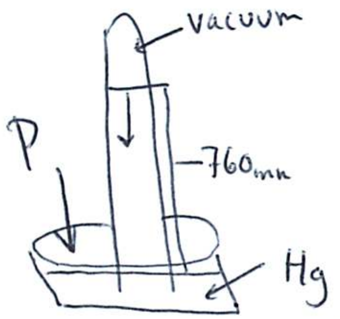
Don't confuse w/ atmospheric → pressure of air around us.

Thermosphere
Mesosphere
Stratosphere
Troposhere

N_2 - 78%
O_2 - 20%
2% Ar
CO_2 0.035%

Measuring Pressure

use barometer → Torricelli 1643 measured atmospheric P



Pressure exerted by atmosphere pushes Hg 760 mm up the tube.

Doesn't matter how long tube is

Always goes 760mm

If this was H_2O only go 34 feet high

If atmospheric P ↑ mm ↑, P↓ mm↓

Units of Pressure

~~760~~ mm Hg, 760mm Hg atmospheric P

torr, ~~1~~ torr = 1mm Hg

atmo → atmosphere → high P → 1atm = 760mm = 760 torr
~~KPa~~

KPa → kilo Pascals 1 ~~kPa~~ atm = 101.3 ~~atm~~ kPa

Know conversions

Do a few examples

STP - standard temp + pressure ($K = °C + 273$)
↳ = 1 atm, 273 K

Boyle's Law → P-V @ constant T → Volume of a fixed mass of a gas varies inversely w/ the P @ const T
Robert 1662

doubling P reduce V by ½ + vice versa
↳ Boyle's law = $V_1 P_1 = V_2 P_2$ know 3 get 4

problem page 329 A = 140 ml

Charle's Law → Temperature + Volume T↑, V↑
Jacques 1787

Increase in gas by 1°C increased V by $\frac{1}{273}$
by 2° ↑ by $\frac{2}{273}$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } V_1 T_2 = V_2 T_1 \quad T = K$$

sample problem 331

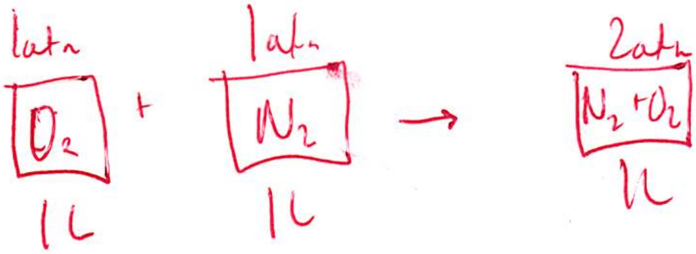
Gay-Lussac's P also ↑ by $\frac{1}{273}$ w/ each 1°C rise
Joseph 1809

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \text{ or } P_1 T_2 = P_2 T_1$$ pg 332

Combined since all related $P_1 V_1 T_2 = P_2 V_2 T_1$

Dalton's Law of Partial P

↳ Pressure of Mixture of Gas = to sum total of individual gases alone



b/c 2x more molecules in same V

$P_T = P_1 + P_2 + P_3$ etc   each molec has = chance to collide against ~~the~~ walls of the container.

Total P = result of total #'s of collisions

Water Displacement → Adds a mix ~~against~~ the eqn.

B/c water vapor get intermingled w/ the gases

↳ gas by H_2O displacement but not practical

water vapor ~~ext~~ exerts a P too (it is a gas)   prob 11.6

↳ Water Vapor P (WVP)

for this to work must set H_2O level even

So → Patm = Pgas in bottle

= Pgas want + P_{H_2O} ← table A-7 varies w/ T

↑

Dry gas